



Reporter

Volume 14, Number 3, Autumn 2005

Nutrient Removal – An Evolving Challenge

The push is on at the USEPA to reduce eutrophication in our nation's receiving waters through increased removal of nitrogen and phosphorus from our wastewater treatment plant discharges. Requirements for enhanced nutrient removal are here for many wastewater treatment facilities and are coming for others. As a result, prudent stewards of wastewater plants in all areas of our country are seeking greater awareness and understanding of nutrient removal issues to guide them in their facility and financial planning.

Nutrient removal is not a new issue, but it can be confusing to implement, particularly with the progression from BNR to EBNR in recent years. When required for your wastewater facility, you will need to understand how regulations will apply now and in the future, and then determine the appropriate means of removal based on the specifics of your existing



At the H.L. Mooney Water Reclamation Facility, EBNR is accomplished in the aeration basins and final filter facility, which includes 10 deep-bed filters.

facilities. Nutrient removal requirements differ depending on the impact of nutrients on the receiving water

and the way regulations are structured in your area to attain selected levels of removal. Some facilities will

—continued on page 2



CSO Research Effort Explores Lower Cost Approach

A research effort to develop and test a lower-cost approach for combined sewer overflows (CSOs) is currently underway in Indiana. Results from this effort could aid the more than 700 U.S. municipalities with combined sewer systems. When wastewater and stormwater flows exceed system capacity, sewage can be

discharged into local waterways or backup in residential areas.

University of Notre Dame assistant professor of civil engineering and geological sciences, Dr. Jeffrey Talley, has assembled a research team that brings together a diverse group of partners. These include the Univer-

—continued on page 4

what's inside

Moline, Illinois Showcases Water Treatment Plant Improvements	5
Upcoming Presentations at WEFTEC 05	6

face greater requirements for removal that increase over time, while requirements for other facilities will be less stringent. In some cases, facilities may receive “seasonal” nutrient removal requirements that will necessitate different levels of removal at different times of the year.

Chemical or Biological

There are many choices of treatment protocols capable of removing nitrogen and phosphorus from wastewater. These protocols fall into two main categories – chemical and biological. Chemical protocols include ammonia stripping and ion exchange for nitrogen removal, and the addition of a metal salt or lime for phosphorus removal. Biological nutrient removal (BNR), though, is often the process of choice due to the familiarity of plant operators with biological treatment, and the capital and operating costs that can be achieved compared to costs for alternative chemical and physical treatment processes. In cases where BNR alone cannot meet nutrient removal requirements, chemical or physical treatment can be used as a supplement.

Biological nutrient removal is commonly the more economical means of removing nitrogen and phosphorus from wastewater. Biological nutrient removal uses naturally occurring microorganisms with oxygen. Facilities for BNR are similar to those for a normal activated sludge process, except that anaerobic and anoxic zones are added. Generally, an existing activated sludge plant can be modified to include these additional zones quite easily. This results in significant capital cost savings compared to the implementation of

chemical or physical nutrient removal. Additionally, operational costs are lower due to reductions in chemical consumption, waste sludge production, and energy consumption.

From BNR to EBNR

Enhanced biological nutrient removal (EBNR) protocols are needed when effluent nutrient removal requirements exceed those that can be accomplished by BNR alone. Biological nutrient removal typically reduces nutrient concentrations to 5-8 mg/l of total nitrogen, although some plants have achieved lower concentrations, and 1-3 mg/l total phosphorus (see table below).

Facilities for BNR are similar to those for a normal activated sludge process, except that anaerobic and anoxic zones are added.

To achieve the lower effluent concentrations required, EBNR uses a supplemental carbon source, such as methanol.

Although nitrogen and phosphorus concentrations can both be reduced using biological processes, the mechanisms for their removal are different. Nitrogen removal is accomplished in two steps. In the nitrification step (which is commonly practiced in conventional wastewater treatment facilities), nitrifying bacteria use oxygen to convert ammonia nitrogen to nitrate. The actual removal of nitrogen from the wastewater requires a further step

called denitrification. In denitrification, nitrates are converted to nitrogen gas under anoxic conditions. Nitrogen gas is then discharged harmlessly into the atmosphere.

Unlike nitrogen, phosphorus has no gaseous form and must be concentrated into a biomass and removed as a particulate with the waste sludge. Biological removal of phosphorus requires an anaerobic zone with the absence of dissolved oxygen and nitrate in the process. This allows phosphorus removal bacteria to thrive and accumulate phosphorus in their cells in excess of nutritional requirements. These bacteria are removed along with the waste sludge.

Biological Choices

Choices of facilities for BNR and EBNR can include just about any of the commonly used biological treatment processes, including activated sludge, rotating contactors, and filters. The key to economical implementation of BNR is to select appropriate removal protocols that can be advantageously adapted to existing facilities. For instance, in activated sludge plants, existing reactors can be modified to include both nitrification and denitrification zones in addition to retaining their capability to remove BOD. Depending on removal protocol selection, additional reactor volume may be required. If this were the case, the economics of performing denitrification in reactors would need to be compared with that of performing denitrification using contactors or filters to determine the more cost-effective alternative. There are many BNR protocols, each of which could be appropriate depending on site-specific conditions. The nitrogen protocols vary in the number and arrangement of treatment steps, but all employ one or more of the following:

- Sequential nitrification followed by denitrification
- Denitrification using influent organics to achieve substrate level denitrification
- Mixed systems where nitrification and denitrification occur in the same reactor

	Concentrations in mg/l	
	Nitrogen	Phosphorus
Influent Raw Sewage	30-40	6-10
Secondary Treatment	15-30	4-8
Biological Nutrient Removal	5-8	1-3
Enhanced Nutrient Removal	3 or less	0.5 or less

—continued on next page

- Manipulation of the environment and feed patterns to achieve nitrification and denitrification at different times
- Simultaneous nitrification and denitrification at different locations in the same reactor

Biological phosphorus removal requires an anaerobic step ahead of BOD and nitrogen removal steps as described previously.

Evolving the Process

The City of Tampa, Florida pioneered nitrogen removal from wastewater in the early 1970's in an effort to save environmentally impacted Tampa Bay from further degradation. Greeley and Hansen designed improvements to the city's Howard F. Curren Advanced Wastewater Treatment Plant that featured a 60-mgd two-stage activated sludge system using pure oxygen and deep-bed denitrification filters. Subsequently, Greeley and Hansen designed an expansion of the plant to 96 mgd.

tankage. This saved the city an estimated \$20 million.

Flexibility is the main characteristic that can be credited for the success of the Howard F. Curren Plant. This flexibility provides the capability to change from a two-stage system to a single-stage system and the ability to denitrify in the nitrification tanks, when needed, to reduce the nitrate load on the filters. As a result of the EBNR improvements at the Howard F. Curren AWTP, Tampa Bay is in the best condition it has been in decades.

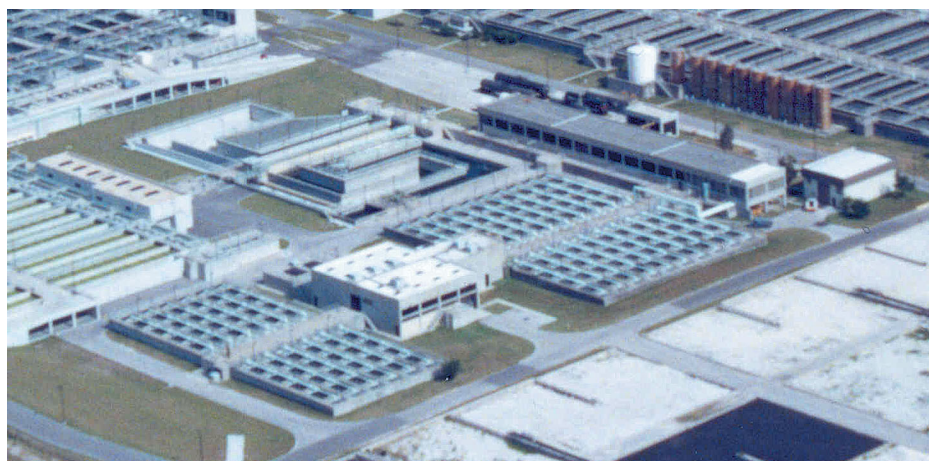
Pilot Studies Uncover Specific Needs

The Prince William County Service Authority's 18-mgd H.L. Mooney Water Reclamation Facility in Woodbridge, Virginia has agreed to a total nitrogen discharge limit of 8 mg/l into Neabsco Creek, which is a tributary to the Potomac River. The plant also removes phosphorus down to 0.18 mg/l based on a monthly average. Pilot studies conducted ahead of the design of the EBNR

efficiencies and determined that the plant could not provide reliable nitrogen removal with the existing tankage alone. Due to insufficient carbon in its primary effluent, modifications for nutrient removal required an EBNR protocol including methanol addition to achieve efficient denitrification.

In addition to the use of methanol, this Greeley and Hansen designed upgrade includes aeration basins modified to allow operation for step feeding primary effluent or as a Modified Lutzack Ettinger Process, as well as a new final filter facility consisting of 10 deep-bed filters. Denitrification is accomplished in the aeration basins and/or the final filters. Total phosphorus concentrations are reduced from an average of 6 mg/l down to 0.1 mg/l with chemical treatment using ferric chloride and polymer. Since start-up of the BNR facilities in 2001, the plant has consistently met or exceeded effluent nutrient requirements. An added benefit of the new EBNR facilities has been the reduction in the quantity of ferric chloride and polymer fed for the reduction of phosphorus.

Greeley and Hansen engineers can assist with developing innovative nutrient removal strategies for wastewater utilities. Our extensive expertise in the theory, design, and operation of nutrient removal facilities results in user-friendly solutions that are practical, flexible, reliable, and easy to operate and maintain. 💧



The Howard F. Curren AWTP features one of the world's largest deep-bed denitrification filter facilities.

As a result of the expansion, existing pure-oxygen reactors are now used only for single-stage carbonaceous treatment, and existing aerobic digestion tanks have been modified to serve as the second nitrification stage in lieu of constructing additional

facilities at the Mooney WRF evaluated alternative BNR operating protocols at a variety of temperatures, anoxic volumes, recycle rates, methanol dosage rates, and solids retention times. These studies, conducted over an 18-month period, identified the benefits of methanol addition to improve nitrogen removal

*For more information regarding biological nutrient removal and other nutrient removal technologies, contact **Carl Koch, Ph.D.** at 302-428-9530 or **Jong Lee, Ph.D.** at 312-578-2314. Koch is a co-chair for development of an upcoming Water Environment Federation Manual of Practice on the operation and maintenance of biological nutrient removal facilities.*